

**METHODS OF SAMPLING AND TESTING**  
**MT 212-04**  
**METHOD OF TEST FOR**  
**DETERMINATION OF MOISTURE AND DENSITY OF IN-PLACE MATERIALS**

**1 Scope:**

- 1.1 This method of test is intended as a means of determining the moisture and/or density of in-place materials, either in the natural state or after compaction.
- 1.2 In-place moisture and density determinations shall be made by the use of nuclear density/moisture equipment. Moisture may be determined by oven drying or by the calcium carbide method, MT-215.

**2 Referenced Documents:**

**2.1 *MT Manual:***

- MT-215 Moisture Content by Calcium Carbide Method
- MT-313 Procedure for Comparing Nuclear Gauge to Core Densities of Bituminous Paving Mixtures

**2 Types of Equipment:**

- 2.1 The types of equipment being used at the present time are:
    - 2.1.1 A portable nuclear moisture/density gauge containing radioactive sources, electronics and rechargeable batteries
    - 2.1.2 Standard Count Reference Block
    - 2.1.3 AC Charger 115v/60Hz and DC Adapter 12v negative ground
    - 2.1.4 Transport case designed and labeled for each specific gauge
    - 2.1.5 Scraper Plate/Drill Rod Guide
    - 2.1.6 Drill Rod and Drill Rod Extractor
    - 2.1.7 Operators Manual and Gauge Booklet
  - 2.2 The nuclear moisture/density gauges are calibrated by the Montana Department of Transportation for testing density of PCC and AC pavements. The gauges are also calibrated for both density and moisture of most soils and soil aggregate mixtures. The calibrations are stored electronically within the gauge.
  - 2.3 Modes of density operation are backscatter and direct transmission (see Operator Manual). Direct transmission reduces surface roughness error and tests a larger volume of material resulting in increased precision. For these reasons, direct transmission is **required** whenever possible when testing soils and base gravels. Moisture may be tested with the source rod in any position.
- 3 Operating Instructions:**
- 3.1 A manufacturer's instructional manual is furnished with each nuclear device and must be consulted for operational procedures. These procedures vary between gauges and must be

followed carefully.

### 3 Operating Instructions: (continued)

- 3.2 NUCLEAR GAUGES SHALL ONLY BE DISTRIBUTED TO PERSONNEL WHO HAVE RECEIVED THE REQUIRED 8 HOUR RADIATION SAFETY AND NUCLEAR GAUGE OPERATION COURSE.** Upon successful completion of this training, the operator will be furnished a certification card which signifies that she/he is fully qualified to operate nuclear gauges. Additionally, gauge operators must attend a 2 to 4 hour refresher course at intervals not to exceed two years. This training will be provided by MDT.
- 3.3** District Materials Supervisors must ensure that each gauge operator has completed an approved operator training course, that their card is up to date and in their possession, and that a radiation monitoring device is properly utilized when handling nuclear gauges.
- 3.4** Some instructional procedures, which should be emphasized, are:
- 3.4.1** The operator should be very familiar with the Operator's Instruction Manual.
- 3.4.2** Always be aware of battery charge status and follow battery care instructions in Operator's Manual.
- 3.4.3** The gauge electronics must be turned on to warm up for a minimum of 15 minutes before taking the daily standard count or testing.
- 3.4.4** Standard counts shall be taken and recorded each day that gauges are put into use.
- 3.4.5** If the daily standard counts are more than 1% for density or 2% for moisture from the average of the previous four counts, procedures should be thoroughly examined and the counts taken again. If these counts also fail, problems with the gauge or procedure are indicated and the appropriate District or Area Laboratory should be contacted.
- 3.4.6** A Stability Test shall be performed:
- 3.4.6.1** Whenever the accuracy of the gauge is in doubt
- 3.4.6.2** Before gauge-core correlations
- 3.4.6.3** At least every two weeks during periods of routine testing.

#### STABILITY TEST

20 One-Minute Standard Counts  
Use Actual Gauge Reading

- 3.4.6.4** Compute Average, (AVG.)
- 3.4.6.5** Compute Square Root of Avg.,  $\sqrt{\text{AVG.}}$
- 3.4.6.6** Compute Standard Deviation, (ST.DEV.)
- 3.4.6.7** Compute Stability Ratio,  $\frac{\text{ST.DEV.}}{\sqrt{\text{AVG.}}} = \text{Stability Ratio}$

### 3 Operating Instructions: (continued)

#### PASSING RATIOS:

	<u>Moisture</u>	<u>Density</u>
Model 3411-B	0.18-0.35	0.18-0.35
Model 3440	0.18-0.35	0.18-0.35

*Note - If the ratio falls outside of the indicated ranges, procedures should be checked and the stability test taken again. If another failure occurs, contact the appropriate District or Area Lab.*

**3.4.7** Shovel, trowel or scraper and straightedge must be used to prepare the test site - **DO NOT USE THE STANDARD TEST BLOCK.**

**3.4.8** Use minus No. 30 sieve size dry sand for seating the gauge base. Whenever available, this sand should be native to the project material.

**3.4.9** A thin layer of sand should remain between the bottom of the gauge and the ground surface. Any unusual voids or air gaps can cause considerable decrease in density readings.

**3.4.10** When testing soils, base gravel, pulverized plant mix materials, cement treated aggregates for acceptance, take two, one-minute counts in the direct transmission mode. Take the first count and record the moisture and density counts. Rotate the gauge 180° around the source rod and take the second count and record the moisture and density counts. The average of the two counts will constitute a test. A valid test consists of density counts in both gauge positions that are within 50 kg/m<sup>3</sup> (3 lb/ft<sup>3</sup>).

**3.4.11** When testing plant mix for density acceptance, four (one minute) tests at 90° intervals as in the pattern defined in MT-313 will be performed. All four one minute tests must be within 40 kg/m<sup>3</sup> (2.5 lb/ft<sup>3</sup>). The average of the four tests will be the final test result.

**3.4.12** Periodic comparison checks should be made using conventional methods.

### 4 Calculations:

**4.1** Use Lab. Form No. 1000A for recording field determinations with Nuclear Devices. These forms are supplied through the Purchasing Services Bureau (Stores) upon request.

**4.1.1** Wet density, dry density, and moisture, all in pounds per cubic foot, can be read directly from the gauge scales. Percent moisture can also be read directly.

**4.1.2** 
$$\frac{\text{Field Dry Density (lbs/ft}^3\text{)}}{\text{Proctor Dry Density}} \times 100 = \% \text{ compaction}$$

**4.1.3** 
$$\frac{\text{Field Wet Density (lbs/ft}^3\text{)}}{\text{Marshall Density}} \times 100 = \% \text{ compaction}$$

**4.1.4** Compare field moisture to optimum moisture from the Proctor determination.

**4.1.5** If problems occur on thin lift plant mix overlays, refer to pages 7 and 8 of this test procedure.

## 5 Radiological Considerations:

- 5.1 The use of nuclear devices is licensed by the Nuclear Regulatory Commission (NRC). The NRC requires a radiation monitoring system for individuals. They also require the leak testing of nuclear gauges every six months.
- 5.2 The Materials Bureau has subscribed to a quarterly TLD badge service. We distribute these badges to all District Materials Supervisors and collect them once a quarter. The District Materials Supervisors issue these badges and instruct each nuclear gauge operator on the following:
  - 5.2.1 Each nuclear gauge operator must wear a TLD badge attached to the front of his clothing or belt at waist level.
  - 5.2.2 These TLD badges must not be transferred from one operator to another.
  - 5.2.3 Whenever badges are not being worn, they must be stored at least 30 feet from nuclear gauges, out of direct sunlight, and away from excessive heat or dampness. **BADGES LEFT NEAR GAUGES ARE ESPECIALLY SUSCEPTIBLE TO UNFOUNDED HIGH READINGS.**
  - 5.2.4 Whenever a TLD badge has a high reading, the individual to whom the badge was issued will be notified and must fill out a report and submit it to the Materials Bureau within five days. It is important that all facts and details be presented accurately and conscientiously including diagrams, distances and times. Statements from supervisors and witnesses are also valuable.
  - 5.2.5 The District Materials Supervisor will keep an up-to-date record consisting of the individual's name, the date the badge was issued, the individual's age, the serial number of the gauge they are using, and the project to which the gauge is assigned. This information, along with the TLD badges will be mailed to the Materials Bureau within ten days after the end of the quarter.
  - 5.2.6 An Occupational Radiation History form (NRC Form 4) must be completed by every employee operating a nuclear gauge. The completed form must be sent to the Materials Bureau.
  - 5.2.7 The leak testing of all nuclear gauges will be performed by personnel in the Materials Bureau or other individuals designated by the Radiation Safety Officer to perform such tests. An up-to-date record of the results of these tests shall also be maintained by the Materials Bureau.

## 6 NRC Licenses and Documents:

- 6.1 All personnel engaged in activities licensed by the NRC can examine the following documents at the Materials Bureau in Helena.
  - 6.1.1 Publication 10 CFR-19, Notices, Instructions, and Reports to Workers and Inspectors.
  - 6.1.2 Publication 10 CFR-20, Standards for Protection Against Radiation.
  - 6.1.3 NCR License No. 25-11498-01, including all conditions and incorporated documents.
  - 6.1.4 Operating procedures applicable to licensed activities.
- 6.2 A notice giving the location of the above documents will be inserted in the nuclear gauge operator's manual or posted in the shipping container. This notice and a map showing the location and telephone number of the regional offices of the NRC will be posted on the bulletin boards or other conspicuous places in each district laboratory and area laboratory. Montana is located in Region IV, telephone (817)860-8100.

**6 NRC Licenses and Documents: (continued)**

- 6.3** The District Materials Supervisors are responsible to see that each gauge operator has completed training in radiation safety and nuclear gauge operations. Proper storage, transporting, and distribution within the districts is also a part of this responsibility.
- 6.4** Inspections will be conducted by the Materials Bureau to verify compliance with the requirements of the license.

**7 Transportation, Storage and Maintenance:**

- 7.1** These instruments require careful handling. The vehicle in which they are transported should be capable of keeping them dry and provide complete security from unauthorized personnel. It should also be equipped with a carrying rack to which the instrument cases can be strapped and locked. This is a precision instrument designed to give many years of good service providing it has proper care.
- 7.2** Requirements for nuclear gauge storage.
- 7.2.1** Storage areas are to be locked and posted with radiation caution signs.
- 7.2.2** When the equipment is not being used, it should be stored in a separate dry room or garage. The temperature in the storage area should be above freezing and the batteries in the device should be fully charged. Never store a device in an area where personnel are working or will be working. Radiation caution signs shall be posted at the entrance door of any storage area.
- 7.2.3** Radiation levels surrounding the storage area shall not exceed two millirems per hour. To help ensure low radiation levels outside the storage area, a gauge should be stored as near the center of the room as practical. Gauges should not be stored above, below or adjacent to a work area. The best way to assure radiation safety is to limit the number of gauges in a storage area. The largest number of gauges to be stored in one area is determined by the outside radiation level which shall not exceed 2 millirems per hour. The Materials Bureau in Helena shall be called to check the outside area to see if the radiation levels are acceptable.
- 7.2.4** Store the gauge fully charged. Battery charging during storage is not necessary but gauges should be given a full charge prior to initial use at the beginning of the construction season.
- 7.3** *Maintaining the Gauge:*
- 7.3.1** The Materials Bureau should be notified immediately when any breakdowns occur. It will be decided at that time whether the gauge should be sent to the Materials Bureau for repairs.
- 7.3.2** Clean and maintain the gauge regularly as recommended in the Operator's Manual.
- 7.4** The Nuclear Gauge Transport paper shall be kept with the nuclear gauge at all times. When transporting a gauge, the certification shall be filled out, visible and within reach of the driver.
- 8 Theory of Operation:**
- 8.1** For theory of operation and other detailed descriptions, consult the manufacturer's manual for the particular model gauge that you are using.